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## AN ECONOMIC STUDY OF THE FARM TRACTOR IN THE CORN BELT.

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Numerous inquiries for information as to the economic value of the gas tractor for farm work are received by the Department of Agriculture from farmers in all parts of the country, and in order to furnish prospective purchasers of tractors with some figures which would be a reliable indication of what might reasonably be expected from these outfits the Office of Farm Management has obtained detailed information from several thousand tractor owners, from all sections of the country, showing just what they are doing in actual service on farms.

From the large number available there have been selected reports from over 200 tractor owners in the State of Illinois<sup>1</sup> whose farms

<sup>1</sup> Most of the reports from which figures were taken for use in this bulletin were obtained during January and February, 1916, though a few were obtained in December, 1915. Over 50 per cent of the outfits reported on were bought during 1915, and no reports were used which related to machines used more than three seasons; from this it will be seen that the data cover only modern outfits. No reports were considered which were furnished by farmers who held agencies for tractors or were otherwise financially interested in the business. The figures should, therefore, represent the opinions of unbiased men.

are typical of corn-belt conditions, and in the following pages are given what are considered the most important facts and figures, from the farmer's standpoint, brought out in the tabulation of the information contained in these reports. Most of the figures have been omitted for the sake of brevity.

Attention is particularly invited to the fact that data on the operation of tractors soon become obsolete because of the changes and improvements which are constantly being made in these outfits, as well as changes in their prices and the prices of fuel, etc. The figures contained herein are correct for conditions as they existed in the spring of 1916, and should be applicable not only in Illinois, but throughout the corn belt, since the farms from which the records herein used were obtained are quite typical, in most respects, of corn-belt conditions in general. Corn is the principal crop grown on practically all these farms, approximately 40 per cent of the entire acreage being planted to this crop. Oats are raised in most cases, the acreage being about one-half as great as for corn, on an average. The next crop in point of acreage is wheat, which is raised to a limited extent on more than half of the farms. Hay, including alfalfa and clover, forms a large percentage of the remaining crops. Both spring and fall plowing is practiced, slightly more ground being plowed in summer and fall than in the spring. The land is mostly level or gently rolling, quite free from stone, for the most part; and while there is a good deal of rather heavy loam the plowing conditions are not severe, except when very dry. The fields are generally regular in shape and range in size from about 20 acres up. (See fig. 1 for labor distribution on a corn-belt farm.)

The above-mentioned facts relative to the general characteristics of the type of farming followed should be kept in mind when considering the figures furnished by tractor owners in this section, as shown in the following summary of the principal facts brought out by a study of the experience of these men as given in their reports:

The chief advantages of the tractor for farm work, in the opinion of the operators, are (1) its ability to do the heavy work and do it rapidly, thus covering the desired acreage within the proper season; (2) the saving of man labor, and the consequent doing away with some hired help; and (3) the ability to plow to a good depth, especially in hot weather.

The chief disadvantages are difficulties of efficient operation and the packing of the soil when damp.

The purchase of a tractor seldom lowers the actual cost of operating a farm, and its purchase must usually be justified by increased returns.

One of the most important points in connection with the purchase of a tractor is to obtain one of suitable size for the farm on which it is to be used. In this connection experienced tractor owners in Illinois make the following recommendations:

For farms of 200 crop acres or less, the 3-plow tractor.

For farms of from 201 to 450 crop acres, the 4-plow tractor, with the 3-plow outfit second choice.

For farms of from 451 to 750 crop acres, the 4-plow tractor, with the 5- and 8-plow outfits tied for second choice.

A farm of 140 acres is the smallest upon which the smallest tractor in common use, the 2-plow outfit, may be expected to prove profitable.

Medium-priced tractors appear to have proven a profitable investment in a higher percentage of cases than any others.

The life of tractors, as estimated by their owners, varies from 6 seasons for the two-plow to 10½ seasons for the 6-plow outfits.

The number of days a tractor is used each season varies from 49 for the 2-plow to 70 for the 6-plow machines.

No definite figures on the repair charges for late model tractors can be given; it would not seem safe, however, to count upon less than 4 per cent of the first cost annually (this representing the average for farm machinery in general).

Under favorable conditions a 14-inch plow drawn by a tractor covers about 3 acres in an ordinary working day. Under unfavorable conditions large gang plows will cover less ground per day per plow pulled than will the small ones.

Two and one-half gallons of gasoline and one-fifth of a gallon of lubricating oil are ordinarily required in actual practice to plow one acre of ground 7 inches deep. The size of the tractor has little influence on these quantities.

Plows drawn by tractors do somewhat better work, on the whole, than horse-drawn plows. In Illinois the depth plowed by tractors averages about 1½ inches greater than where horses are used.

Efficient operation is essential to success with a tractor, and proficiency usually can be obtained more cheaply and easily by previous study and training than by experimenting with one's own tractor.

With a proficient operator the tractor is a very reliable source of power.

The use of the tractor for custom work is usually an indication that the home farm is not large enough to utilize it economically. The doing of custom work with the tractor, on the whole, appears to be a questionable practice, although nearly 45 per cent of machines are used for such work to some extent.

A tractor displaces on an average about one-fourth of the horses on the farm where it is used.

On a large number of Illinois farms brood mares constituted 33 per cent of the work stock before the purchase of the tractor. The use of the tractor increased this proportion only 3 per cent.

Experienced tractor owners do not consider even a 2-plow outfit profitable on a farm of less than 140 acres. The average size of farm on which 2-plow outfits are used in Illinois is 270 acres.

The 4-plow tractor is most recommended by experienced owners.

Both increases and decreases in the crop yields are reported from the use of the tractor, although favorable effects are more common than unfavorable. However, increases are not sufficiently frequent to warrant a farmer placing much dependence on the tractor in this respect.

It should be clearly understood that the figures given represent average results obtained in actual service and not the maximum possibilities of the tractor. These averages are believed to be worth

more to a farmer in determining the possible value of a tractor for his work than are maximum figures from tests no matter how carefully conducted. The latter would represent, at best, only a limited number of machines and conditions, while averages here given represent a large number of machines operated by incompetent as well as competent operators under both favorable and unfavorable conditions. A prospective purchaser may reasonably count upon equaling the average performance of his neighbors. He should strive, of course, to equal the maximum performances of experts, but should not depend upon being able to accomplish like results in order to justify investing in a tractor. For example, an outfit with sharp, new plows, operated by an expert, may plow an acre of ground with, say, one gallon of gasoline, but since under ordinary conditions, with plows that have been sharpened several times and perhaps are not in perfect adjustment, the fuel consumption will ordinarily equal the average given herein,  $2\frac{1}{2}$  gallons, it is obvious that the farmer should use the average figure in calculating the possible value of the tractor for his work.

It is not the purpose of this bulletin to influence the farmer either for or against the tractor as a source of power, but only to assist him in determining whether his individual conditions justify the use of such power. The question of whether a tractor will prove profitable on a particular farm is a problem in farm management which must be worked out for each individual farm; in some cases it will prove profitable, while in others it will not, depending upon conditions.

#### ADVANTAGES AND DISADVANTAGES OF THE TRACTOR.

The theoretical advantages of mechanical power for farm work are obvious but it is believed a prospective purchaser of a tractor would be interested in knowing what the men who have used tractors have found to be their principal advantages and disadvantages in actual practice.

Several hundred Illinois tractor owners were asked the questions; "What do you find to be the principal advantages of a tractor for farm work?" and "What are the principal disadvantages?"

A summary of the replies to these questions discloses the following interesting points:

The ability of the tractor to do the heavy work and to do it quickly, thus covering the desired acreage within the proper season, was considered the principal advantage. The saving of man-labor and the doing away with hired help was placed next. The ability to plow to a good depth, especially in hot weather, was placed third, while economy of operation, the displacement of horses, and the ability to use the tractor day and night were not mentioned by very many owners, although they are usually considered, theoretically, to be decided advantages.

Under disadvantages, difficulty of efficient operation and packing of the ground when damp were the principal points. Expense came next, while delays and inability to use the tractor for many kinds of work for which horses could be used were given by several owners.

While other advantages and disadvantages were mentioned, they were not given by a large number of owners.

### ECONOMY.

The fact that reduction in the cost of operating a farm was not emphasized as an advantage of the tractor, while expensiveness is frequently mentioned as a disadvantage, should be carefully considered by a farmer who contemplates buying a tractor with the hope of reducing his present operating expenses.

A comparison of the cost of doing farm work with a tractor with the cost of doing the same work with horses means practically nothing, for the reason that several horses must ordinarily be kept on the average farm even where the tractor is used. Comparisons must, therefore, be made between the cost of operating a farm with horses alone and the cost of operating with a tractor and a certain number of horses.

In any such comparison there are a number of factors which must be considered and which vary widely in different cases. No attempt will be made herein to make direct comparisons, which would, at best, apply to but a very small percentage of cases. Average figures, based on reports of experienced tractor owners, will be given for the various factors, thus enabling a farmer to figure out what he may reasonably expect of a tractor under his own conditions.

In any such calculations, however, it is necessary to consider not only the relative expense with the two methods, but the relative results. The value of such features will vary on different farms; on some they will be very important while on others they will mean little.

### SIZE OF FARM AND TRACTOR.

Every improved farm machine reduces the man-labor required for farm operations, thus permitting one man to accomplish more work and so farm more land than with the older methods. However, it is an obvious and well-known fact that a farm business must be of sufficient size to permit of the economical use of an improved machine in order to justify the necessary investment therein. That is, many small farms must either use the old methods or hire a modern outfit, because the small amount of work to be done each year does not warrant owning the machine.

Among the more important facts disclosed by a study of the use of the tractor for farm work are those relating to the increase in the

acreage which can be farmed by one man, when a tractor is used in connection with horses, over that farmed with horses alone. Approximately 75 per cent of tractor owners in Illinois state that the tractor has proven a profitable investment to them. Of this number about one-third, after the purchase of the outfit, increased the acreage which they were farming, the increase averaging about 120 acres per farm. On the other hand, of the men who found the tractor unprofitable, only one-twentieth increased their acreage after purchasing the tractor.

These figures are significant, not only because a large percentage of the men who found the tractor profitable increased their acreage, but also because of the considerable percentage of the entire number of tractor owners who have enlarged their farms, as compared with the smaller percentage of all Illinois farms of comparable size which have increased their acreage in recent years. (See U. S. Census, 1910, Vol. V, p. 276.)

Farm-management studies repeatedly have demonstrated the fact that a great many farms are not large enough to furnish economical employment for the equipment which they possess; that is, the various implements are capable of doing the work on a larger acreage within the time which the seasons allow, and that the purchase or rental of additional land often will increase the gross receipts considerably without increasing the operating expenses to any great extent.

The following figures as to the smallest size of farm on which tractors of from 2 to 5 plow capacity can be profitably used are based on the statements of about 200 tractor owners located in the State of Illinois. (Table I.) The acreages given are the averages of the figures furnished by these men in reply to the question: "What do you consider the minimum size of farm on which a tractor the size of yours can be used profitably in your section?"

TABLE I.—*Minimum acreages upon which tractors are profitable.*

(Averages based on estimates of about 200 Illinois tractor owners.)

Size of tractor. <sup>1</sup>	Minimum size of farm on which it is profitable (owners' estimates).
2-plow .....	140
3-plow .....	200
4-plow .....	250
5-plow .....	320

<sup>1</sup> In all cases the size of the tractor is referred to by the number of 14-inch plows pulled rather than by the horsepower ratings. This is done for the reason that the different manufacturers do not use a uniform method of rating their outfits, thus making a comparison of the different tractors by their horsepower ratings practically valueless. It is believed that the course here followed of grouping by the number of plows pulled under conditions which are not only fairly uniform but which represent average conditions offers a more reliable comparison than would be obtained by grouping according to the horsepower ratings.

Attention especially is called to the fact that these figures represent the smallest size of farm for which these tractors should be purchased, in the opinion of men who have had experience with them, and not the size on which they can be used most profitably. A farmer who is contemplating the purchase of any particular size of tractor and whose farm is smaller than the acreage above given for that size should consider carefully before acting contrary to the opinions of experienced men.

The average sizes of farms on which tractors of different sizes are being used in the State of Illinois are shown in Table II and are considerably above the minimum figures as given above.

TABLE II.—*Average sizes of farms upon which tractors of different sizes are being used.*

(Averages based on estimates of about 200 Illinois tractor owners.)

Size of tractor.	Average size of farm.
2-plow .....	270
3-plow .....	330
4-plow .....	365
5-plow .....	420

While a few of the larger outfits are used the numbers are not sufficient to furnish reliable averages, and, furthermore, such outfits frequently are bought principally for custom work, in which case the size of farm becomes of less importance.

It is necessary that the proper size of tractor be procured in order to obtain the fullest degree of satisfaction. A tractor which is not powerful enough for the work required of it will, of course, prove more or less unsatisfactory, and to exchange it for a larger one entails an expense which would be unnecessary if the right size were obtained in the first place. On the other hand, an outfit which is much too large may be too clumsy or expensive in operation to make it economical for a great deal of work for which one of the proper size could be used with satisfaction and economy.

It is interesting to note, in comparing the data in Table III with that in Table IV, that the 50 Illinois tractor owners having farms of 201 to 300 crop acres had bought outfits varying in size from 2-plow to 10-plow, 36 per cent of them having bought tractors capable of pulling more than 4 plows. Only 8 per cent of them now recommend anything larger than a 4-plow tractor for farms of this size. Eighteen per cent of them originally bought 2-plow machines, but only 14 per cent now recommend this size for their farms. The most significant fact is that while only 46 per cent originally bought 3 or 4 plow outfits, 78 per cent now recommend these sizes.



In Table III are shown the sizes of tractors bought by 146 farmers in the State of Illinois, arranged according to the amount of land being farmed.

TABLE III.—*Tractors of different sizes bought by 146 farmers in Illinois, arranged according to acreage cropped.*

Acres cropped. <sup>1</sup>	Average acres cropped. <sup>1</sup>	Total number of tractors bought.	Percentage of different sized tractors bought.						
			2-plow tractors.	3-plow tractors.	4-plow tractors.	5-plow tractors.	6-plow tractors.	8-plow tractors.	10-plow tractors.
			<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
200 or less.....	156	39	33	23	23	13	3	0	5
201 to 300.....	252	50	18	22	24	14	8	12	2
301 to 450.....	361	39	10	18	33	13	16	10	0
451 to 750.....	503	18	5	17	33	33	0	22	6
All purchases.....		146	18	20	25	16	8	10	3

<sup>1</sup> Includes only land actually tilled and planted to crops.

It will readily be seen that there was considerable difference of opinion among these men as to the best size of tractor to buy when they first invested in such an outfit. The 146 machines are pretty generally distributed as to size, both in the individual groups and in the aggregate. It will be noticed that 37 per cent of them were distributed among the 5, 6, 8, and 10 plow outfits, while 18 per cent pulled only 2 plows.

As compared with these figures, it is interesting to note that these same men, after experience with their tractors, have come to a much more definite and uniform opinion as to the proper size of outfit for their farms, as shown by their recommendations set forth in Table IV.

From this it will be seen that only 4 per cent of the farmers with less than 200 acres of crops now recommend anything larger than a 4-plow tractor for this size of farm, although Table I shows that 21 per cent originally bought outfits of larger size. None of them recommends a tractor capable of pulling more than six plows. The 3-plow tractor is recommended by 41 per cent of the owners, while 31 per cent recommend 4-plow, and 23 per cent 2-plow, outfits. In other words, 95 per cent of these men recommend either 2, 3, or 4 plow tractors.

TABLE IV.—*Tractors of different sizes recommended by the 146 tractor owners in Illinois shown in Table I.*

Acres cropped. <sup>1</sup>	Average acres cropped. <sup>1</sup>	Total number of recommendations.	Percentage of different sized tractors recommended.						
			2-plow tractors.	3-plow tractors.	4-plow tractors.	5-plow tractors.	6-plow tractors.	8-plow tractors.	10-plow tractors.
200 or less.....	156	39	<i>Per ct.</i> 23	<i>Per ct.</i> 41	<i>Per ct.</i> 31	<i>Per ct.</i> 2	<i>Per ct.</i> 2	<i>Per ct.</i> 0	0
201 to 300.....	232	50	14	32	46	2	4	2	0
301 to 450.....	361	39	8	21	38	13	10	10	0
451 to 750.....	503	18	0	11	39	22	6	22	0
All recommendations.....		146	13	29	39	8	5	6	0

<sup>1</sup> Includes only land actually tilled and planted to crops.

The figures for the group of farmers with from 201 to 300 acres of crops already have been referred to, and the conclusions to be drawn from those for the last two groups are similar to those mentioned for the first two, although the percentage of men recommending the larger sizes of tractors naturally increases with the additional acreage, while that for the smaller sizes drops off correspondingly, no one recommending the 2-plow tractor for farms having over 450 acres of crops.

The principal points relating to the best size of tractor as brought out by the experience of tractor owners in Illinois as shown in Table IV may be briefly summarized as follows:

For farms having 200 acres, or less, of crops, a 3-plow tractor is considered the most desirable, while a 4-plow outfit would probably be better on this size of farm than one pulling only 2 plows.

For farms having from 201 to 300 acres of crops a 4-plow outfit is generally believed to be most suitable, while either a 3 or 2 plow machine would be better than one pulling more than 4 plows.

For farms having from 301 to 450 acres of crops the 4-plow tractor is also the favorite, although a larger outfit would probably be more satisfactory than a smaller one.

For farms of 451 to 750 acres of crops the 4-plow tractor is again given a slight preference, although the 5 and 8 plow sizes are each recommended by 22 per cent of the tractor owners in this group, while none recommends the 2-plow, and only 11 per cent favor the 3-plow machines.

Judging by figures obtained at the beginning of 1916, slightly more 3-plow tractors were sold in Kansas and Illinois during 1915 than any other size. The 2-plow outfits were a close second, with the fours third, but some distance behind either the threes or twos.

It should be mentioned, however, that these machines were grouped according to the number of plows pulled in actual practice, as given by the farmer, which resulted in placing some makes of tractors of exactly the same size partly in one group and partly

in another, rather than including them all with the same size according to the manufacturer's rating. From the figures thus obtained it appears that the percentages of different sized tractors bought in Illinois and Kansas during the past year were approximately as shown in Table V, assuming that the number of outfits on which records were obtained is a reliable indication of the percentages of the total numbers.

TABLE V.—*Tractors bought in Illinois and Kansas in 1915, classified by size (194 reports).*

Size of tractors.	Percentage bought.
2-plow.....	30
3-plow.....	42
4-plow.....	16
5-plow.....	6
6-plow.....	3
8-plow.....	2
10-plow.....	1

As compared with these figures, the percentages of different sizes recommended by the men who have had experience with tractors are shown in Table VI.

TABLE VI.—*Tractors recommended by 146 owners, classified by size.*

Size of tractors.	Percentage recommending.
2-plow.....	13
3-plow.....	29
4-plow.....	39
5-plow.....	8
6-plow.....	5
8-plow.....	6
10-plow.....	0

Particular attention is invited to the decrease in the percentage of 2 and 3 plow tractors recommended as compared with those bought, and the corresponding increase in the percentage of 4-plow outfits recommended over the same size bought.

It is significant that the 4-plow tractors give more general satisfaction in Illinois than any other size, as indicated by the percentage of favorable reports from their owners, as shown by Table VII.

TABLE VII.—*Favorable reports, classified by size of outfit (99 reports).*

Size of tractor.	Percentage of owners reporting the tractor a profitable investment.
2-plow.....	70
3-plow.....	73
4-plow.....	86
5-plow.....	76
6-plow.....	82
8-plow.....	82
10-plow.....	60

Where modern self-lifting gang plows are used, one man ordinarily handles the entire outfit in plowing no matter what size gang is used.

The 4-plow size seems to meet best the tractor requirements of the average farm in Illinois; it enables plowing to be performed at a much faster rate than is usual when horses are employed. The man-labor is also reduced when using this size tractor, as one man attends to four plows at one time, instead of only two, as is ordinarily the case where horses are used. Furthermore, this size of tractor is generally powerful enough to operate practically all of the machines which are commonly found on the average farm, including the ensilage cutter and medium-sized grain separator. At the same time it is not too expensive in operation to prohibit its use for many odd jobs which do not demand a great deal of power. These facts probably account, to a great extent, for its popularity.

There are, of course, factors other than the size of farm which must be considered in order to determine the best size of tractor to buy, and mention will be made of them in the following paragraphs. In cases where these factors do not exist or are of no effect, however, it would seem advisable to procure the sizes of outfits recommended by men who have had experience with tractors on farms of practically the same size, provided, of course, that the conditions were similar in each case. In this connection attention is particularly invited to the general type of farming followed by the men whose figures are shown herein, as mentioned on page 2.

In deciding as to the size of outfit to purchase, careful consideration should be given to the various jobs for which the tractor will be used, and care exercised to obtain one with ample power for the heaviest work which will be required of it. This may be either field or belt work; probably it will be the latter more often than the former. Quite frequently the work of a tractor in driving a grain separator or ensilage cutter requires more power than the plowing, and in such cases the tractor bought should be powerful enough to handle the belt work properly.

On the other hand, if the belt work which will be required of the tractor will not demand a great deal of power, while there may be a considerable amount of plowing which it will be desired to complete within a limited season, the tractor should be capable of pulling enough plows to enable the work to be performed within the time available.

Then, too, there are cases where only a small amount of belt work is required and most of the field work will be done with horses, the tractor being wanted merely to make extra power available in rush seasons, or to relieve the horses during hot spells. In such cases the small 2-plow outfits frequently have proven most satisfactory. Such an outfit has the additional advantage of not necessitating a large

investment, and on this account is frequently recommended by experienced men as a good size to buy at first, in order to gain experience in the use and care of tractors.

If it is desired to use the tractor for custom work on neighboring farms or for road work, the power requirements for such work should be ascertained and care exercised to choose an outfit with sufficient power to handle the work satisfactorily.

As a general rule it is better to err through buying an outfit with too much power rather than too little, but this should not be interpreted as recommending the purchase of the largest sizes. It refers rather to the too common practice of getting a 2-plow outfit to do work which should properly be done by a 4-plow machine. The decrease in the percentage of men recommending 2-plow tractors, as shown in Table IV, compared with the percentage of men who bought this size, as shown in Table III, is perhaps as significant as the increase in the percentage recommending 4-plow outfits in comparison with that recommending larger sizes.

#### COST OF TRACTOR OUTFIT.

While the cost of a tractor should not be the prime consideration, it is one of the first points which a farmer must consider. The prices of the various makes of outfits vary considerably for machines of the same capacity. The figures given in Table VIII are averages for a considerable number of each size, but it should be borne in mind that some makes will cost more than the prices shown, while others will be less.

TABLE VIII.—*Cost of tractor outfits (148 reports).*

Size of tractor.	Cost of complete outfit.	Cost of tractor.	Cost of plow.	Cost per plow pulled.
2-plow .....	\$554	\$501	<sup>1</sup> \$53	\$277
3-plow .....	1,262	1,086	176	421
4-plow .....	1,560	1,296	264	390
5-plow .....	2,034	1,653	381	407
6-plow .....	2,352	1,962	390	392
8-plow .....	2,798	2,212	586	350

<sup>1</sup> Many farmers use a horse gang plow with the small outfits, and as these cost less than a 2-bottom engine plow it makes the average price of the plows lower than for ordinary 2-bottom engine gangs.

The price which a farmer can afford to pay for a tractor for use on his farm depends upon a number of factors, and this is another point on which no definite figures can be given at the present stage of tractor development. However, it is particularly interesting to note that the outfits costing between \$500 and \$1,200 have proved profitable in a somewhat greater percentage of cases than either lower or higher priced machines. This was shown by grouping the reports of tractor owners according to the cost of the outfit, as given in Table IX.

TABLE IX.—*Favorable reports, classified by cost of outfit (147 reports).*

Outfits costing between—	Percentage of owners reporting them profitable.
\$355 and \$500.....	71
\$501 and \$700.....	82
\$701 and \$900.....	88
\$901 and \$1,200.....	86
\$1,201 and \$1,500.....	77
\$1,501 and \$1,800.....	72
\$1,801 and \$2,850.....	73

These figures would seem to indicate that a farmer who pays more than \$1,200 for a tractor will find it comparatively difficult to make it profitable, while buying exceptionally low-priced outfits frequently does not pay, partly because they are often cheap in quality as well as in price, and partly because they are too small to do the work economically.

It is interesting to compare these figures with those appearing on page 10, giving the percentage of favorable reports for different sizes of tractors.

#### LIFE OF THE TRACTOR.

The number of years a tractor will be of service is, of course, an important factor in determining its value for farm work.

Gas tractors have been on the market such a short time that it is obviously impossible to obtain any very definite figures as to just how long a modern tractor may be expected to last on a farm.

The average of the estimates of about 200 owners of comparatively new tractors in Illinois as to the length of time their outfits will give satisfactory service is 8 years. These estimates, of course, can not be accepted as of much value and are in reality probably overestimates. While present-day tractors are perhaps better made than those of a few years ago, it is to be noted that tractors that have been worn out did not on the average last 8 years. It would at least be on the side of safety for a prospective purchaser to count on a shorter period of service than 8 years. It should be borne in mind that the men making these estimates probably assumed that it would be possible to obtain repair parts for their outfits at any time. Judging by past experience in the tractor field, however, quite a number of the concerns now in the business will have ceased to exist 5 years hence, and repair parts for still other machines will not be obtainable except at exorbitant prices even if the manufacturers are still in the business, as new designs will have been adopted, and it will not pay to keep spare parts for old outfits in stock except in cases where they have been sold in large numbers.

From Table X it will be seen that the estimated life of the small tractors is less than for the large ones.

TABLE X.—*Estimated life of tractors (132 reports).*

Size of tractor.	Average of estimates of owners as to probable length of service.
	<i>Years.</i>
2-plow.....	6
3-plow.....	8
4-plow.....	8½
5-plow.....	9
6-plow.....	10½

Just how much weight should be given to these figures is difficult to determine, but, as before stated, they are probably of little value. However, the figures as to the average number of days the different sizes of tractors are used per year should be quite accurate, as these are not estimates, but known numbers (Table XI).

TABLE XI.—*Average number of days used per year (96 reports).*

Size of tractor.	Number of days used during year.		
	At custom work.	On home farm.	Total.
2-plow.....	3	46	49
3-plow.....	3	46	49
4-plow.....	7	53	60
5-plow.....	25	40	65
6-plow.....	31	39	70

From these figures it will be seen that the large sizes are used fewer days on the home farm, but a much greater number at custom work than are the small outfits, indicating that the farms on which the large ones are used (see page 8) are too small to furnish them economical employment.

These figures probably will appear low, at first glance, but when it is remembered that on farms where horses do all the work they are used, on an average, only about 100 days annually, it will be seen that where both horses and tractor are used, even though the number of horses is somewhat reduced, the tractor will not have employment for as many days annually as did the horses. The horses kept will do some of the work, which will, of course, decrease the amount to be done by the tractor. But if the tractor did all the work formerly done by the horses it would not normally be employed 100 days per year, inasmuch as it does the work faster. It should be

remembered that practically all farm operations must be carried on within limited periods, and that between these seasons there will often be no field work which the tractor can do, either on the home farm or for neighbors. The fact that weather and soil conditions are such as to permit of field work with a tractor does not mean that there is such work to be done. Farm management plays an important part in organizing the farm so as to provide employment for the tractor during as many days as possible. Such organization involves the planning of a crop rotation which will furnish a large amount of work which the tractor can do, the elimination of a maximum number of horses, and the distribution of the work over a long period. However, the rotation should include only such crops as can be grown at a profit in that particular section. The desirability of having more land where a tractor is used than where horses only are employed, in order to keep the tractor busy during the limited working seasons, will be readily apparent when considering the tractor's place in farm management.

In Table XII is shown the estimated average life of the different sizes of tractors in terms of total number of days of use based on the figures given in Tables X and XI.

TABLE XII.—*Estimated average life of tractors in days of service.*

Size of tractor.	Average life in days.
2-plow.....	294
3-plow.....	392
4-plow.....	510
5-plow.....	585
6-plow.....	735

### REPAIRS.

Any figures on the expense of keeping a tractor in repair are of necessity very general. The amount of repairs required depends upon a great many factors, such as the nature of the work, the care the outfit receives, both when used and when idle, etc. Most tractors are kept in repair by the manufacturers during the first year's service excepting for such items as are caused by some fault of the operator. It is not until the second year, therefore, that the owner bears the full expense.

Of 99 tractor owners in Illinois who had used their outfits one season or less 52 reported that they had spent nothing for repairs. The others had had repair bills varying from a few cents to a hundred dollars or more. Very few machines go through their second season without repair charges, the amount depending somewhat,



of course, upon the size and cost of the machine. The figures thus far obtained on the cost of repairs would seem to indicate that the repairs on the 2-plow outfits are slightly higher in proportion to first cost than those for the 3 and 4 plow machines. It would appear also that the average repairs borne by tractor owners the first year will amount to approximately  $1\frac{1}{2}$  per cent of the first cost of the tractor, while for the second year they are about double this figure.

Figures on the repairs required by any machine during the first two years of its life, however, are of little value, as with most farm machines the repairs are comparatively low during the first two years, but maintain a fairly constant percentage thereafter.

The average percentage of the first cost of farm machinery in general which is expended annually for repairs is slightly over 4 per cent,<sup>1</sup> and it is improbable that the annual repairs required by a tractor during its life would fall below this figure. This would mean a total expenditure for repairs, during the eight years reported by operators as the tractor's life, equal to 32 per cent of its first cost.

#### WORK DONE PER DAY.

The amount of land covered per day by a plow drawn by a tractor is usually slightly greater than that covered by a horse-drawn plow. The acreage covered by two different machines, each pulling the same number of plows, often varies considerably because they travel at different speeds. Theoretically a 14-inch plow when drawn by a tractor should cover approximately 3 acres in an ordinary working day of 10 hours, as the average plowing speed is slightly more than 2 miles per hour. This will hold true in actual practice when the plowing conditions are favorable, provided the outfit does not give trouble. That is, a 2-plow machine should plow 6 acres and a 10-plow outfit 30 acres per day, provided both travel at the average rate of speed and are kept moving. However, under conditions where trash is to be turned under, and frequently clogs the plows, or where other obstructions cause delays on account of the plows, each plow drawn by a large tractor will cover much less ground in a day than one drawn by a small outfit, because the delays will naturally be in proportion to the number of plows pulled. A delay on account of 1 plow on a 2-plow outfit stops only 1 other plow, while on a 10-plow rig, for example, it stops 9 other plows. To illustrate, supposing a man operating a 2-plow tractor was compelled to stop 10 times during a day for each plow, in order to clear it of trash, and spent three minutes each time (which would not be unusual), the loss of time during the day would amount to a half hour

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<sup>1</sup> See U. S. Department of Agriculture Bulletin No. 338.

for each plow, or but one hour total loss. Each plow would have done nearly as much work as in plowing continuously. On the other hand, a man operating a 10-plow tractor under the same conditions would have to clear each plow the same number of times in proportion to the acreage covered, resulting in a total loss of three or four hours during the day. In such case each plow would have done much less work than under favorable conditions.

In view of these facts it is apparent that when plowing under unfavorable conditions large gang plows do not cover as much ground per day per plow as do the smaller ones. However, one man accomplishes considerably more work with the large outfits, even under such conditions.

In Table XIII are given some figures showing the average acreage covered by different-sized outfits in Illinois, as recorded by farmers, which indicate what should be expected under average corn-belt conditions, where there is more or less material to be turned under. It will be noticed that the decrease in the acreage per plow is somewhat irregular. This is due to the fact that in some of the groups certain makes predominate and the average acreage covered corresponds with the speeds of these outfits; that is, where most of the tractors travel at comparatively high speeds the acreage covered per plow is high and vice versa.

Another influencing factor is that in some of the groups figures have been included for machines which the owners are requiring to pull one more plow than should be demanded of them, and which do not cover as much ground as should be covered by a machine in the same group which is pulling a normal load. It does not pay to overload a tractor any more than it does to overload a horse. Three plows behind a 2-plow tractor will cover only a little more ground, as a rule, than will the two plows, because the tractor usually will travel a little slower, partly because the motor is overloaded and does not maintain its proper speed, and partly because the drive wheels will slip more with a load heavier than the machine was designed to pull; as a consequence delays on account of small holes or slight grades will be more common, as will also mechanical difficulties. These remarks apply particularly to the 2 and 3 plow tractors; the 3-plow group contains some machines which were not designed to pull 3 plows, but which have been included because the owners are using them with that number. The 2-plow group contains some of the same make and are doing nearly as much work. This group also includes several outfits which travel considerably faster than the average.

TABLE XIII.—Average acres covered per day and per plow, by the several sized outfits working under Illinois corn belt conditions (145 reports).

Size of tractor.	Acres covered per net day of 10 hours.	Acres covered per day per plow.
2-plow.....	6.7	3.4
3-plow.....	8.2	2.7
4-plow.....	10.4	2.6
5-plow.....	12.6	2.5
6-plow.....	15.3	2.5
8-plow.....	20.2	2.5
10-plow.....	23.0	2.3

### FUEL AND OIL CONSUMED IN PLOWING.

The average amount of fuel consumed in plowing an acre of ground with a tractor in Illinois as reported by tractor owners is slightly more than  $2\frac{1}{2}$  gallons. The size of tractor seems to have little influence on the amount required, or on the quantity of lubricating oil used, the latter averaging approximately one-fifth of a gallon per acre. The depth of plowing averaged very nearly 7 inches.

Gasoline is used as fuel by most of the tractor owners in Illinois, the average price paid for same during 1915 being 12 cents per gallon, while lubricating oil averaged 32 cents per gallon.

At these prices the cost for gasoline and oil per acre would be about 36 cents, but the prospective purchaser of a tractor should not make the mistake of assuming that this will be the entire cost, and furthermore, he should remember that the price of gasoline was exceptionally low during 1915. At the beginning of 1916 the average price in Illinois was in the neighborhood of 18 cents, or 50 per cent higher than the figures above mentioned. At 18 cents, the cost of gasoline per acre would be 45 cents, to which should be added about 6 cents for oil, or a total of 51 cents for fuel and oil.

Kerosene for fuel is used to some extent, but is not reported to be as satisfactory in the majority of small outfits as it was in the larger ones used a few years ago. Even where used the amount consumed for a given amount of work is usually greater than for gasoline, thus tending to offset the difference in price. As a rule a little more difficulty in operation is experienced where kerosene is used, and slightly more time is lost per day.

### QUALITY OF WORK.

Forty-eight per cent of tractor users report that the quality of the work done by the tractor is better than that done by horses, 46 per cent state it is the same, while only 6 per cent report that it is poorer. This applies principally to plowing. Forty-one per cent of owners in Illinois consider tractors unsatisfactory for use on plowed land, while 59 per cent state they are satisfactory for such work.

The quality of work done in plowing does not depend so much upon the tractor as upon the plow and its adjustment. Under aver-

age conditions the work done by most engine gang plows when properly adjusted is fully equal, if not superior, to the work done by either a walking or gang plow drawn by horses and operated by a skillful plowman. If a job of plowing where a tractor is used is not satisfactory, it is not usually the fault of the tractor but of the plow or, more probably, due to misadjustment of the plows. Of course, in fields with obstructions, sharp angles, etc., the tractor may be responsible for poor work because of its clumsiness, but under most conditions the plows and the operator determine the quality of the work done. The tractor's part is to furnish the power to pull the plows.

This point should be kept in mind by farmers who select their tractors by visiting demonstrations of different makes of outfits. The quality of the work done by the different machines should be of value in selecting a good *gang plow*, but it is practically worthless in determining the value of the different *tractors*. It is quite possible that a tractor of very inferior quality may be pulling a good gang plow, well adjusted, and doing much better work than an outfit of first-class quality which is pulling a poor plow, or one that is out of adjustment.

The average depth of plowing done with tractors in the State of Illinois, as reported by their owners, is slightly less than 7 inches. The average depth they had previously plowed with horses was about  $5\frac{1}{2}$  inches. While this deeper plowing is ordinarily considered as indicating a better quality of work, it does not appear to have had any marked effect on the crop yields, as mentioned elsewhere.

#### OPERATION.

In view of the fact that difficulty in operation is mentioned by tractor owners as the principal disadvantage of the tractor, as shown on page 5, it seems pertinent to state that while any man of ordinary ability can operate and care for a gas tractor very satisfactorily after a little study and experience, it is decidedly unwise for him to undertake to gain the necessary experience by experimenting with his own machine. In most cases he can obtain the experience more cheaply elsewhere. Experience in running stationary engines or automobiles, while of some value, is not enough; the mere starting of the motor, changing of gears, and stopping are simple matters, and any farmer can quickly learn to do these, but the important thing is the ability to detect trouble the minute it begins to develop, and to be able to remedy it promptly instead of allowing it to run along until an expensive delay results.

A great many owners report that it is extremely difficult to get hired help capable of operating a tractor satisfactorily. Where a tractor is to be operated by hired help it is very important for the

owner to understand the proper care of the outfit in order to see that it is not abused.

The fact that a tractor does demand a certain amount of knowledge on the part of the operator can scarcely be considered a disadvantage, inasmuch as the necessary training can be obtained easily and at a very nominal expense. It is to be regretted that so many men will ignore the opportunities for equipping themselves for the proper operation of a tractor before attempting to run one.

That it pays to spend a few days in gaining experience under a competent instructor is attested by a great many tractor users. That it is unwise to attempt to run a tractor without such preparation has also been demonstrated many times. One farmer writes:

I had no experience with the tractor when I started and would have made \$500 more during the season, if I had had the same experience when I started in the spring as I had in the fall when I quit.

Many others could truthfully make similar statements.

With the increasing use of tractors, as well as of automobiles and stationary engines, farmers are rapidly becoming familiar with the care and operation of gas engines. At the same time tractors are being improved and simplified, so that difficulties in operation are growing less each year. One generation of well-trained and competent operators will disseminate information so that future generations will acquire knowledge on the subject as unconsciously, yet as thoroughly, as the average farmer's son acquires his knowledge of horses.

The mistake should not be made of assuming that any boy can operate a tractor in an efficient manner; it is a job which only a proficient operator can handle properly.

### RELIABILITY.

The reliability of a tractor depends very largely upon the ability of the operator. Of about 200 tractor owners in Illinois, 57 per cent report that their outfits were not out of commission a single day when needed during the past season. Of the remaining 43 per cent, the average number of days their tractors were out of commission when needed was 7. This average, however, does not include the experience of 7 men who stated their machines were out of commission nearly all the time and one who said half the time.

The reports of tractor owners indicate that with a careful and proficient operator a gas tractor is a very dependable source of power; occasional slight delays probably will be encountered, but serious ones will be exceptional. With a careless or incompetent operator, serious delays are apt to be frequent.

About 90 per cent of tractors in Illinois are operated by the owner or some member of his family. The reports of these men show

that an average of about three-fourths of an hour is lost per day on account of trouble with the tractor itself.

### DISPLACEMENT OF HORSES.

Many men look to the tractor to enable them to do away with the use of horses for farm work, at least in great part. To date, however, the tractor has not displaced horses to the extent commonly expected by purchasers, but its greatest advantage, as before mentioned, lies in the fact that it does the heavy work quickly, and thus completes it within the proper season, since it places at the farmer's command a large amount of power when needed.

The tractor does displace horses to some extent, but only in about two-thirds of the cases where it is used on the same number of acres previously farmed. In these instances the horses displaced average only about four, and represent slightly less than 50 per cent of the cost of the tractor outfit. The number of horses displaced does not appear to vary to any great extent with the size of the outfit, about as many horses being laid off after the purchase of a small outfit as after buying a large one. The number will vary under different conditions, however, the principal influencing factors being the number of acres farmed per horse and the distribution of the work throughout the year. In the corn belt, horses are seldom displaced on farms where the average tilled acreage per horse is 30 or more. On the farms in Illinois where horses were displaced by the tractor, one horse had been kept for each 20 acres of tilled land. After the purchase of the tractor one horse was kept for each 30 acres of tilled land, or approximately the same as on farms on which no horses were displaced.

There is much work on most farms for which it is neither practicable nor profitable to use the tractor. This is especially true in the corn-belt section, where cultivating frequently requires more power at one time than any other farm operation. Few, if any, tractors, according to reports received, are utilized for such work with entire satisfaction, and it is, therefore, necessary to retain a considerable number of horses after the tractor is bought.

In figure 1 is shown the distribution of horse labor on a typical corn-belt farm, from which it will be seen that the peak load, that is, the greatest amount of work, comes about the end of May, which is the season when corn cultivating is at its height.

On 92 Illinois farms where no change in the acreage was made after the purchase of the tractor, an average of 12 horses per farm had previously been kept. Two hundred and sixty-three horses were displaced on these farms, an average of not quite three horses per farm. On 31, or about one-third of these farms, no horses were laid off.

The raising of colts is an industry of considerable importance on farms in the corn belt, and it would seem natural to expect that where tractors were bought and the work stock thus relieved of the heavy field work the percentage of brood mares kept would be increased, and that the chances of raising more and healthier colts would be enhanced. It was found, however, that on a large group

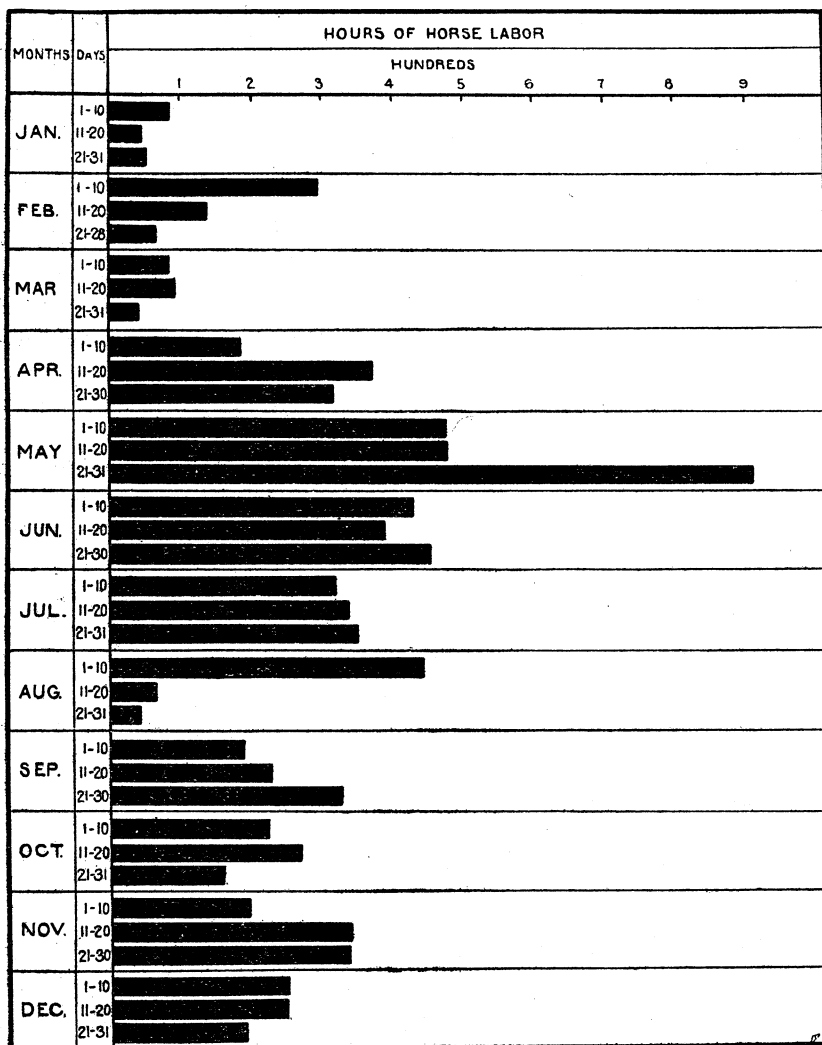


FIG. 1.—Showing distribution of horse labor on a typical corn-belt farm (in Illinois) of 200 acres, with about 120 acres of corn, 45 of oats, and 30 of hay (11 horses).

of farms in Illinois the brood mares constituted 33 per cent of the work stock before the tractors were bought, and while the work stock was decreased to some extent after the purchase of the tractor, the percentage of brood mares increased only 3 per cent, making the percentage now kept amount to 36 per cent.

### CUSTOM WORK.

Forty-five per cent of Illinois tractor owners reporting use their outfits for custom work to some extent. A great many of them bought their outfits with the idea of using them for such work, while others procured them for use on their own farms only and undertook custom work at the request of neighbors or because it seemed to offer an opportunity for the tractor to help pay for itself.

In some cases a farmer is justified in using his tractor for such outside work. On the whole, however, it is a rather reliable indication that the home farm is not large enough to utilize a tractor economically.

There would even seem to be some doubt as to whether it pays at all to use the tractor for custom work. Of the 45 per cent of Illinois owners reporting who used their tractors for custom work, one-third stated that it did not pay them to do custom work. It should be noted, too, that comparatively few farmers consider their entire expenses when figuring the profits from custom work, most of them ignoring depreciation charges and including only fuel, oil, labor, and such repairs as may be required during the time the outfit is used at such work.

On the whole, it is preferable that the machine be kept busy on the home farm, where the owner may derive the maximum profit from it. Certainly a tractor owner is not justified in neglecting his own work to work on neighboring farms at the rates usually paid, yet such practice is not uncommon. Most of the custom work done with tractors in Illinois, however, is belt work, and is done principally during slack seasons.

The data show that nearly all of the custom work is done with outfits of medium or large size owned on farms of comparatively small size, the smaller machines not being powerful enough for most of the belt work offered, and those on the larger farms being kept busy at home.

### EFFECT OF USE OF TRACTOR ON CROP YIELDS.

The reports of corn-belt tractor owners who have used their outfits for three seasons would indicate that although the yields are occasionally increased by having the plowing done at the proper time and by deeper and more thorough preparation of the seed bed in hot weather, such results are too infrequent to warrant a farmer in depending upon this feature to any great extent, especially in view of the fact that decreases also occur occasionally on account of the packing of the soil when damp. Increases in yields are most frequent with wheat, partly because timeliness in plowing has more effect on its yield than on other crops and partly because it usually does best in a firm seed bed.



Although the depth of plowing done with the tractor averages about  $1\frac{1}{2}$  inches greater than that done with horses, this seems to have had, as mentioned elsewhere, a negligible effect on yields. This is perhaps somewhat contrary to what is generally expected, but is doubtless accounted for by the fact that deep plowing alone does not necessarily increase the yields, other good farming methods and practices being required in connection therewith in order to make it profitable.

### TRACTOR EQUIPMENT.

The tractor has not yet passed the stage of rapid development which most new machines undergo; in fact it has not progressed far enough to reach the stage of general elimination of outfits of poor design in favor of a standard type. Nevertheless, many of the outfits now on the market are proving profitable to men who are using them. At the same time the tractor is making rapid progress—so rapid, in fact, that field equipment for use with it, with the exception of gang plows, has not kept pace with such development.

It is obviously impossible to obtain maximum results with a tractor when it is used with implements designed primarily for use with horses, and the objection of many tractor owners that the tractor can not be used with profit for certain types of field work will probably cease to hold good in the near future. There is every indication that there will soon be available farm implements designed especially for use with the tractor which will increase its value for farm work, making it practicable and economical for many kinds of field operations where it is now both impracticable and uneconomical.

This is evidenced by the many innovations in harvesting machinery and other attachments, designed to be used on the tractor as a unit, rather than drawn as separate units in the manner followed when horses are used. While this should not be considered as a recommendation of attachments the utility of which has not yet been demonstrated, there would seem to be little doubt that the development of equipment specially designed for use with the tractor, together with the standardization of design and reduction in price which normally result from manufacture in quantity, will greatly enhance the value of the tractor for farm work.

In accord with the purpose of this bulletin, it is not desired to draw conclusions from the facts and figures as given in the preceding pages, but to leave it to the farmer himself to calculate the probable value of a tractor for use on his particular farm. As previously stated, it is not the purpose to influence the farmer either for or against the tractor as a source of power, but only to enable him to judge whether his individual conditions justify the use of such power.